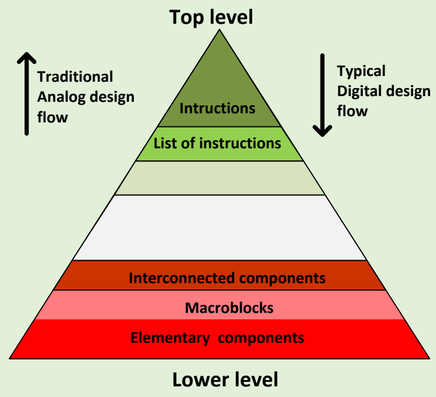
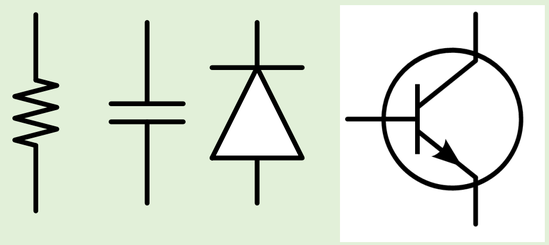
# Analog electronic teaching - a new approach for bipolar transistors

Carlos Felgueiras[1]; Catarina Santos[2]; Gustavo Alves[3];
André Fidalgo[4]; Clovis Pertry[5]; Luis Schlichting[6]
{mcf[1], 1111641[2], gca[3], anf[4]}@isep.ipp.pt; petry@ifsc.edu.br[5], schlicht@ifsc.edu.br[6]
[1,2,3,4] ISEP / DEE – Rua Dr. António B. de Almeida – 4200-072 Porto – PORTUGAL
[5, 6] IFSC – Campus Florianópolis - BRAZIL

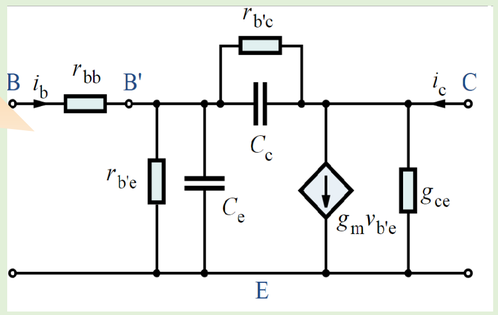
**1- Electronic Design:** Two opposite design flow methodologies;
the analog one is harder.



**2 - Component:** Transistor is considered an elemental component.

**3 - Model: The traditional transistor equivalent model is too complex for beginners.**




**However it has :**
- Three regions of operation (i)
- Collector-Emitter equivalent for each region (ii)
- Two boundaries of operation (iii)
- Two working regimes (iv)

**4 - Proposed methodology**
a) Team work: teacher + student
b) Student:
- Define acceptable definitions for (i, ii, iii, iv)
- Select type of Learning Support Means (LSM):
  - Internet sites
  - Internet slides
  - Internet movies
  - (Books – By teacher suggestion, for comparison)
- Mean criteria selection:
  - No suggestions where made
  - Should be as more realistic as possible
- LSM personal perceptions (not an evaluation!)

**5 - Transistor working concepts perceptions for selected sites**

| Transistor Operation | Transistor Working Concepts | Site # | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| Transistor Regions | Regions identification | 5 | 1 | 2 | 1 | 1 | 4 | 5 |
| | Regions sequence | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Region characteristics | 1 | 1 | 2 | 1 | 1 | 2 | 2 |
| | Region boundaries | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Collector – Emitter equivalent | 2 | 1 | 2 | 1 | 1 | 1 | 3 |
| Transistor Regimes | Regimes identification | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| | Regions for Switching regime | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

**6 - Transistor working concepts perceptions for slide sites**

| Transistor Operation | Transistor Working Concepts | Slide site # | | | | |
|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** |
| Transistor Regions | Operation regions identification | 2 | 5 | 3 | 5 | 4 |
| | Regions sequence | 2 | 4 | 1 | 1 | 3 |
| | Region characteristics | 1 | 3 | 4 | 2 | 3 |
| | Region boundaries | 1 | 1 | 1 | 2 | 3 |
| | Collector – Emitter equivalent | 1 | 1 | 5 | 2 | 1 |
| Transistor Regimes | Regimes identification | 1 | 1 | 2 | 2 | 1 |
| | Regions for Switching regime | 1 | 1 | 1 | 2 | 1 |

**7 - TRANSISTOR WORKING CONCEPTS PERCEPTIONS FOR SELECTED FOR VIDEOS**

| Transistor Operation | Transistor Working Concepts | Video site # | | | |
|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** |
| Transistor Regions | Operation regions identification | 5 | 1 | 2 | 1 |
| | Regions sequence | 1 | 1 | 1 | 1 |
| | Region characteristics | 1 | 1 | 2 | 1 |
| | Region boundaries | 1 | 1 | 1 | 1 |
| | Collector – Emitter equivalent | 2 | 1 | 2 | 1 |
| Transistor Regimes | Regimes identification | 1 | 1 | 1 | 1 |
| | Regions for Switching regime | 1 | 1 | 1 | 1 |

**8 - TRANSISTOR WORKING CONCEPTS PERCEPTIONS FOR BOOKS**

| Transistor Operation | Transistor Working Concepts | Book # | | |
|---|---|---|---|---|
| | | **1** | **2** | **3** |
| Transistor Regions | Operation regions identification | 3 | 4 | 3 |
| | Regions sequence | 3 | 3 | 3 |
| | Region characteristics | 3 | 4 | 3 |
| | Region boundaries | 3 | 3 | 3 |
| | Collector – Emitter equivalent | 3 | 3 | 3 |
| Transistor Regimes | Regimes identification | 3 | 3 | 3 |
| | Regions for Switching regime | 3 | 3 | 3 |

**Conclusions**
a) This work was based in a single individual sample;
b) Learning Support Means (LSM) received poor acceptance;
c) Other Alternative Support Means are under development;
d) For these, a broader test sample was used;
e) Preliminary results from this test are encouraging to further pursue this work